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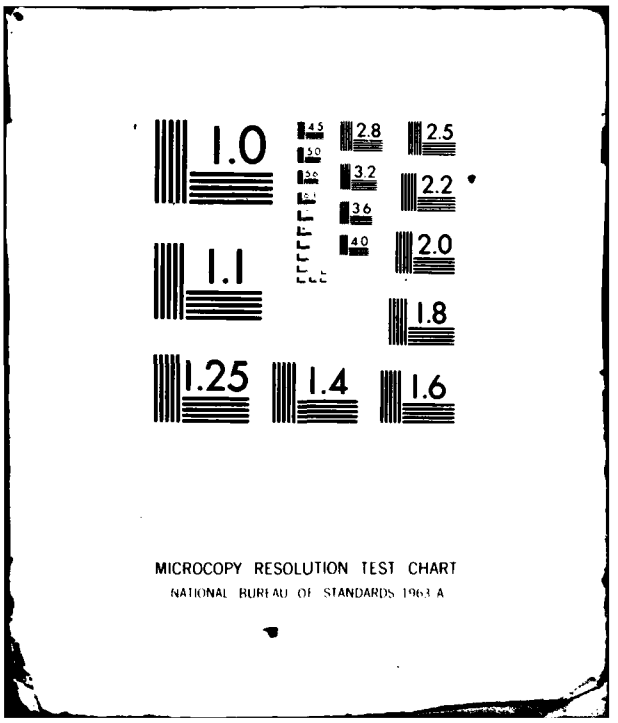
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Report No. FAA-RD-80-113
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OMEGA TRANSMITTER OUTAGES
JANUARY TO DECEMBER 1979

Lorraine Rzonca

FEDERAL AVIATION ADMINISTRATION TECHNICAL CENTER
Atlantic City Airport, New Jersey 08405

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DATA REPORT

OCTOBER 1980

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Prepared for

U. S. DEPARTMENT OF TRANSPORTATION
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16. Abstract

An investigation of Omega transmitter outages during 1979 was conducted with emphasis on the occurrence of simultaneous downtimes. Data presented includes frequency and duration of outages and total yearly percentage shutdown for each transmitter, with scheduled outages specifically noted. The most significant dual outage lasted more than 5 days when Norway antenna repairs were coincident with Argentina annual maintenance.

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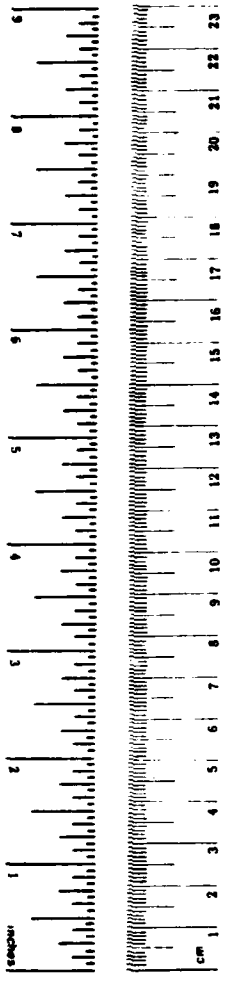
AD-A093 425

METRIC CONVERSION FACTORS

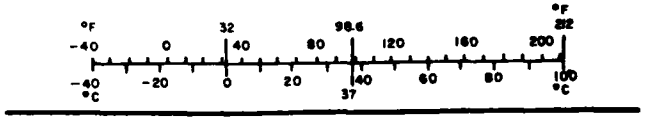
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5 9 (after subtracting 32)	Celsius temperature	C



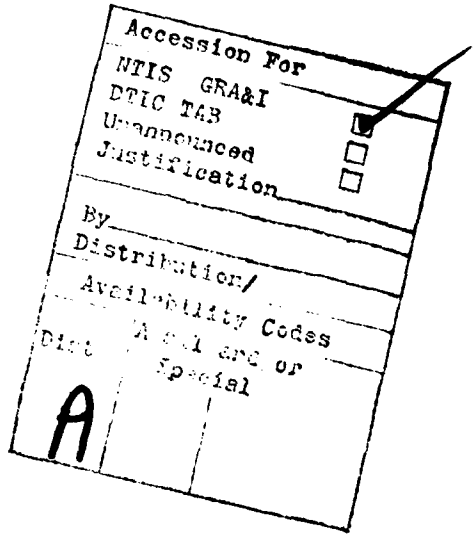
Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This project is included under Technical Program Document (TPD) 04-162, subprogram 043-311-520. For further information, contact The Federal Aviation Administration Technical Center, Systems Test and Evaluation Division, Attention: Lorraine Rzonca, ACT-100B, Atlantic City Airport, New Jersey 08405.



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INTRODUCTION

PURPOSE.

The purpose of this continuing investigation is to note the frequency of occurrence and the duration of simultaneous outages at two or more Omega transmitters, and to examine the possible impact of these outages upon Omega coverage. Results reported on a yearly basis will serve as a comprehensive history of Omega transmitter outages.

BACKGROUND.

This study is a continuation of an investigation initiated in 1978 and reported in the National Aviation Facilities Experimental Center (NAFEC) Technical Letter Reports Nos. NA-78-61-LR, "Omega Transmitter Outages, January 1976 to June 1978," and NA-79-26-LR, "Omega Transmitter Outages, January to December 1978."

Since the Omega system has not yet reached its ultimate level of operation, transmitters are shut down occasionally for various modifications and adjustments. Prior notification of the scheduled shutdowns is available from the United States (U.S.) Coast Guard Omega Navigation System Operations Detail (ONSOD), either by teletype or recorded telephone message. In addition to scheduled outages, occasional unexpected problems may necessitate shutdown of the transmitter equipment. Omega transmitter outages during each week are listed in ONSOD teletypes and are also published in "Daily Phase Values and Time Differences, Series 4," of the U.S. Naval Observatory.

PROCEDURE.

Published values of Omega transmitter downtimes of duration greater than 2 minutes have been entered on disk file for the Honeywell 66/60 computer for the time period January to December 1979. (For the purposes of this report, any downtime extending into the following day is counted as a separate occurrence; therefore, the maximum duration possible is 1,440 minutes.) The processed data has been examined with respect to the frequency and duration of downtimes, occurrence of simultaneous outages, and total yearly shutdown for each transmitter (with scheduled downtime specifically noted).

Identification of each transmitter is made according to the following codes:

1 = Norway = A
2 = Liberia = B
3 = Hawaii = C
4 = North Dakota = D
5 = LaReunion = E
6 = Argentina = F
7 = Trinidad = G
8 = Japan = H

The number code is used throughout this report; the letter code is that used in ONSOD teletype messages.

DISCUSSION

Table 1 identifies stations which were simultaneously off the air for 7 minutes or longer, and lists the date, start time, and duration of each simultaneous outage. Transmitters scheduled to be down during the indicated time period are denoted by asterisks. (Scheduled downtime is defined as the actual outage which occurred within the approximate time frame previously published for the anticipated shutdown.) Durations less than 7 minutes were excluded since most Omega navigation systems for airborne use are capable of "dead-reckoning" for 7 minutes and would not be subject to a large adverse impact due to signal loss for this time period. Only one occurrence (North Dakota - Trinidad on June 29, 1979) involved unscheduled outage (of both transmitters) for a period of 28 minutes; North Dakota required tower repairs, and Trinidad

TABLE 1. SIMULTANEOUS OFF-AIR TIMES $\geq$ 7 MINUTES

Date	Transmitters	Duration (min)	Start Time (GMT)
3-16-79	*1, *6	740	1140
3-17-79	*1, *6	1439	0001
3-17-79	*1, *6, 8	33	1139
3-18-79	*1, *6	1439	0001
3-19-79	*1, *6	1439	0001
3-20-79	*1, *6	1439	0001
3-21-79	*1, *6	1439	0001
3-22-79	*1, 5	29	1302
3-23-79	*1, *6	97	1310
3-24-79	*1, 8	114	1231
3-26-79	*1, *6	78	1600
3-29-79	*1, 6	9	2013
3-30-79	*1, 5	10	2009
3-31-79	*1, 7	52	0717
3-31-79	*1, 6	13	1309
4-01-79	*1, *2	639	0600
4-04-79	*2, 6	30	1023
4-26-79	2, *8	49	0045
4-26-79	2, *8	7	0255
6-29-79	4, 7	28	1522
8-22-79	*4, 5	19	1448
8-24-79	*4, 5	27	2300
10-24-79	5, *8	12	0528
10-24-79	7, *8	17	2005
10-24-79	3, *8	10	2313

*Scheduled off-air time

Transmitter Code: 1 = Norway, 2 = Liberia, 3 = Hawaii, 4 = North Dakota, 5 = LaReunion, 6 = Argentina, 7 = Trinidad, 8 = Japan

NOTE: There were no simultaneous outages $\geq$ 7 minutes during the months of January, February, May, July, September, November, or December.

went down during a commercial power failure. Most of the simultaneous outages were due to the coincidence of the Norway antenna repairs with the Argentina annual maintenance. Because of this situation, one triple outage (33 minutes) occurred on March 17, 1979, when Japan went down due to a transmitter overload. Excluding Norway and Argentina outages during March and the first day of April, the simultaneous outage of greatest duration occurred on April 26, 1979, when Liberia went down for 49 minutes (due to commercial power failure), while Japan was off-air for scheduled maintenance. Between April 4 and October 24, the simultaneous off-air durations ranged from 7 to 49 minutes, with a median of 19 minutes. For the entire time period between March 16 and October 24, the simultaneous off-air durations ranged from 7 to 7,935 minutes (5 days, 12 hours), with a median of 28 minutes (including the Norway and Argentina scheduled outages).

Table 2 lists the four triple outages which occurred during 1979. Three of these lasted for less than 7 minutes; all of them involved the Norway - Argentina pair. The longest triple outage (33 minutes) involved the Japan station, down due to transmitter overload.

Table 3 sums the durations of simultaneous outages for each station pair for 1979. The yearly total for each pair is listed together with subtotals for times when only one of the two stations was scheduled down, and times when both stations were scheduled down; if neither station was scheduled down, zeroes appear in both of the "Scheduled" columns. Station pair Norway - Argentina was the major contributor, as discussed previously. Only two station pairs showed simultaneous outages for which neither station was scheduled down: North Dakota - Trinidad for 28 minutes, when North Dakota required tower repair and Trinidad had a commercial power failure; and North Dakota - Japan for 4 minutes, when North Dakota was down due to an insulator problem and Japan went down for 4 minutes.

Table 4 shows the number of occurrences of simultaneous outages of various durations for the years 1976 through 1979. The figures for 1979 are misleading because the lengthy continuous outage of Norway - Argentina (from March 16 to 21) was counted as six occurrences rather than one (each new day was counted as a separate occurrence). If the numbers are decreased by five, they correspond quite well with those for 1977. The figures for 1978 are higher, since most transmitters were being modified to transmit their assigned unique frequencies.

Table 5 compares total duration of simultaneous outages which occur during the allocated annual maintenance period, and those which occur under conditions of normal operation during a given month. The high figures for March were due to the necessity for extensive antenna repairs at Norway; if Norway had been fully operational for the entire period, only one simultaneous outage (33 minutes) for Argentina - Japan would have occurred. Similarly, for April, Norway downtime produced 92 percent of the simultaneous outage time. The 32 minute total duration in June, under normal operating conditions, was due to insulator problems at the North Dakota transmitter, which required about 40 continuous hours of downtime. Ordinarily, when unexpected hardware problems did not interfere (as exemplified by the figures for July, August, and October), durations of simultaneous outages were $\leq$ 0.1 percent of a month (50 minutes) even during routine annual maintenance.

Table 6 shows the monthly percentage of total and scheduled downtime for each transmitter; table 7 lists the yearly percentage. Norway leads in yearly downtime (4.5 percent) due to the antenna failure in March; LaReunion, Argentina, and North Dakota are next with 4 percent. The bulk of this

TABLE 2. TRIPLE OUTAGES

Date	Transmitters	Duration (min)	Start Time (GMT)
3-17-79	*1, *6, 8	33	1139
3-19-79	*1, 2, *6	4	1325
3-20-79	*1, *6, 8	3	0126
3-20-79	*1, 2, *6	6	2304

*Scheduled off-air time

TABLE 3. YEARLY TOTAL DURATION OF SIMULTANEOUS OFF-AIR TIMES FOR EACH TRANSMITTER PAIR

Transmitter Pair	Duration Off-Air (min)		
	Total	One Scheduled	Both Scheduled
1,6	8,182	26	8,156
1,2	656	17	639
1,8	150	150	0
2,8	68	68	0
1,7	59	59	0
4,5	58	58	0
2,6	54	54	0
1,5	47	47	0
6,8	36	36	0
4,7	28	0	0
7,8	17	17	0
5,8	17	17	0
1,4	11	11	0
3,8	10	10	0
2,5	6	6	0
2,3	5	5	0
4,8	4	0	0
2,7	3	3	0

TABLE 4. NUMBER OF OCCURRENCES (N) OF SIMULTANEOUS OFF-AIR TIMES $\geq$ X MINUTES

	1979	1978	1977	1976
X	N	N	N	N
5	33	46	26	9
7	25	35	22	8
15	19	19	14	7
30	14	15	10	3
60	10	8	5	3
120	7	6	1	1

TABLE 5. COMPARISON OF SIMULTANEOUS OUTAGES DURING MAINTENANCE PERIODS AND DURING NORMAL OPERATION

		Total Duration (mins)		Monthly Percentage	
Month	Transmitter Maint. Period	During Maint.	Normal Operation	During Maint.	Normal Operation
Mar	3/6 - 3/26 (Argentina)	8156	264*	18.3	0.6*
Apr	4/1 - 4/12 (Liberia)	691	68	1.6	0.2
Jun		0	32	0.0	0.1
Jul	7/1 - 7/14 (LaReunion)	6	0	0.0	0.0
	7/15 - 7/20 (Hawaii)	-	-	-	-
	7/26 - 7/27 (Norway)	-	-	-	-
Aug	8/14 - 8/28 (N. Dakota)	58	0	0.1	0.0
Oct	10/22 - 10/26 (Japan)	44	0	0.1	0.0

*Due to Norway down for antenna repair.

TABLE 6. PERCENTAGE OF TIME TRANSMITTER IS OFF-AIR

Transmitter	Month	Percentage Time Off-Air	Scheduled Percentage Time Off-Air
Norway	3	50.0	50.0
	4	2.3	0.0
	7	0.9	0.9
	Year	4.5	Year 4.3
Liberia	1	0.3	0.0
	4	28.9	28.7
	5	0.1	0.0
	6	0.2	0.0
	7	0.1	0.0
	10	0.3	0.0
	11	0.2	0.0
	12	0.6	0.3
	Year	2.5	Year 2.4
Hawaii	2	1.0	0.9
	4	0.3	0.0
	7	1.9	1.9
	9	0.1	0.0
	11	0.2	0.2
	12	3.4	3.4
	Year	0.6	Year 0.5
North Dakota	5	0.1	0.0
	6	7.9	1.3
	8	36.5	36.5
	10	0.1	0.0
	11	1.6	1.4
	12	0.1	0.0
	Year	3.9	Year 3.3
LaReunion	1	2.9	0.0
	3	0.1	0.0
	4	0.3	0.0
	5	0.1	0.0
	6	0.5	0.0
	7	42.1	41.9
	8	0.2	0.0
	10	0.2	0.0
	12	0.4	0.0
	Year	4.0	Year 3.6
Argentina	1	1.0	0.3
	2	0.6	0.0
	3	43.7	43.6
	4	0.3	0.0
	5	0.1	0.0
	10	0.2	0.1
	11	0.2	0.0
	12	0.2	0.0
	Year	3.9	Year 3.7
Trinidad	1	0.1	0.0
	3	0.1	0.0
	6	0.1	0.0
	7	0.6	0.5
	9	0.7	0.4
	10	0.1	0.0
	Year	0.1	Year 0.1
Japan	3	0.3	0.0
	4	1.3	1.2
	8	0.1	0.0
	10	11.1	11.1
	Year	1.1	Year 1.0

Note: Excludes monthly cumulative off-air times < 25 minutes.

TABLE 7. 1979 YEARLY PERCENTAGE OF OFF-AIR TIME

Transmitter	Scheduled	Unscheduled
Norway	4.3	0.2
Liberia	2.4	0.1
Hawaii	0.5	0.1
North Dakota	3.3	0.6
LaReunion	3.6	0.4
Argentina	3.7	0.2
Trinidad	0.1	0.0
Japan	1.0	0.1

downtime occurred during annual maintenance periods. A significant unscheduled contribution to downtime for LaReunion occurred in January due to transmitter current overload. North Dakota experienced insulator problems and need for tower repairs during June; hence, the large percentage of unscheduled downtime during that month. Liberia showed 2.5 percent yearly downtime, almost all of it during the annual maintenance period. Except for North Dakota and LaReunion, for which emergency repairs had been necessary as noted above, no more than 0.2 percent of the yearly downtime was unscheduled. This is an improvement over previous years, when the upper limit on unscheduled downtime was 0.4 percent.

Table 8 lists the scheduled period (as published by the U.S. Coast Guard) for annual maintenance of each transmitter, and the total hours included within this period. The periods vary in length, depending upon the anticipated maintenance requirements. The percentage of these scheduled hours during which the transmitter was actually shut down is listed in the far right column. Although the allotted time for annual maintenance varied from 1.3 days (Norway) to 21 days (Argentina), the actual cumulative time ranged from 0.3 days (Norway) to 13 days (LaReunion), with a median of 8.6 days and an average of 7.1 days. This average is the same as that for the previous year.

Figure 1 depicts the monthly total number of occurrences of simultaneous downtimes of duration greater than X minutes, where X = 7, 30, 120. All the simultaneous outages of long duration were clustered in March and April 1979. The greatest number of simultaneous downtimes lasting more than 30 minutes occurred in March, due to the Norway repairs during Argentina's annual maintenance time. During the month of April, long dual outages also occurred, but at one-third the frequency compared to March. During the previous year (1978), most of the simultaneous outages greater than 30 minutes took place in June and July, with several also in January, March, August, September, and October. Of interest is the fact that during both 1978 and 1979 the total number of occurrences of dual outages were identical for X = 120 (7 occurrences) and for X = 30 (15 occurrences); there were 35 occurrences in 1978 as opposed to 26 occurrences in 1979 for X = 7.

However, in 1978 only three occurrences included in each X represented the situation where both transmitters were scheduled off; in 1979 nine occurrences for X = 7 and X = 30, and seven occurrences for X = 120 represented both transmitters scheduled off simultaneously. During 1979 there were two occurrences (28 minutes and 4 minutes, both in June) when neither transmitter was scheduled down; during 1978 there was one such occurrence (18 minutes in December).

TABLE 8. TIME TRANSMITTER IS DOWN FOR ANNUAL MAINTENANCE

Transmitter	Scheduled Period for Annual Maintenance Dates	Total Hours	Percent Total Hours Actually Off
Norway	26 Jul 0800 to 27 Jul 1600	32	21.9
Liberia	1 Apr to 11 Apr, 0600-1800; 12 Apr 0800 to 15 Apr 1600	212	97.5
Hawaii	15 Jul 0000 to 20 Jul 0400	124	11.6
North Dakota	14 Aug 1200 to 3 Sep 2100	489	55.5
LaReunion	1 Jul 0000 to 14 Jul 2400	336	92.9
Argentina	6 Mar 0000 to 26 Mar 2400	504	59.6
Japan	22 Oct 0000 to 26 Oct 0800	104	79.8

Note: Trinidad transmitter omitted since it is a temporary station.

Note: Cumulative maintenance-time (actual) ranged from 0.3 to 13 days, with an average of 7 days.

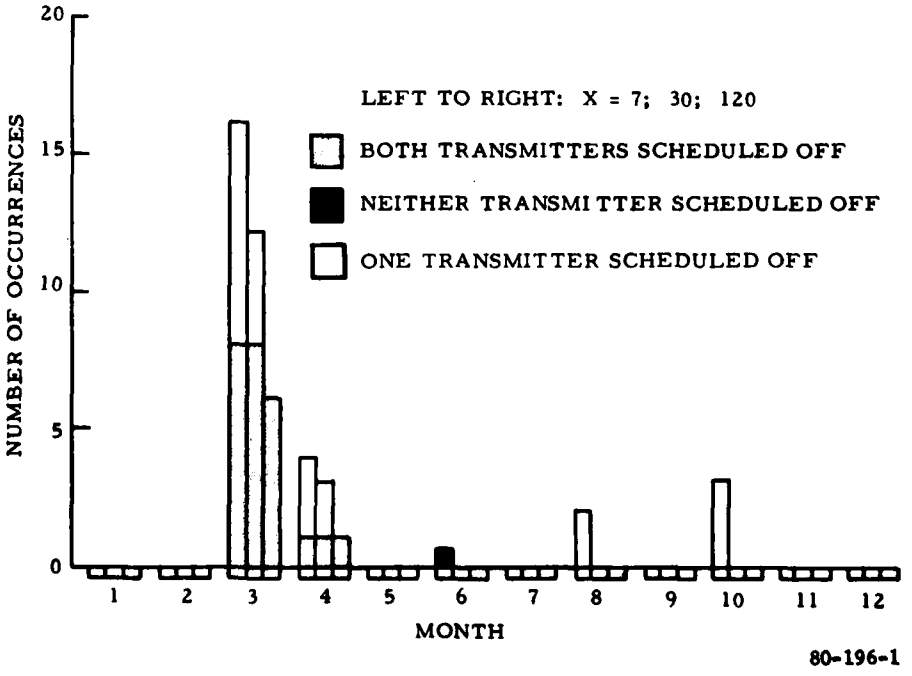


FIGURE 1. SIMULTANEOUS OFF-AIR TIMES OF DURATION $\geq$ X MINUTES

Simultaneous outages, especially those of long duration, may critically affect signal coverage in those geographic locations which receive fewer than five acceptable signals (adequate signal-to-noise ratio, good geometry, no modal interference). A first approximation in determining these geographic locations may be obtained from a composite Omega coverage diagram distributed by ONSOD (a modification of this diagram is shown as figure 2). This diagram indicates regions in which predicted signal-to-noise ratio for 10.2 kilohertz (kHz) is greater than -20 decibels (dB) and in which modal interference is expected to be insignificant. The signal-to-noise ratios were computed by assuming all daylight propagation conditions along each path, and by applying noise data for the Greenwich mean time (GMT) of local noon at each point. This represents a condition of (generally) high local noise levels and high signal attenuation, but minimal modal interference. By examining the coverage diagram, it may be seen that the Atlantic Ocean west of Africa and north of South America is adequately covered by five stations, 1-2-3-4-6 (the temporary Trinidad station is not included); if both Norway and Argentina are out (as in March 1979 for 5.5 days) and the Liberia signal exhibits modal interference, then only Hawaii and North Dakota provide adequate signals and Omega coverage is effectively lost. The Western Pacific near Japan has four stations, 1-3-5-8, providing adequate coverage. (On this diagram, station 7 is Australia, not yet operational.) The loss of Norway and Japan during the triple outage (1-6-8 for 33 minutes on March 17, 1979) theoretically produced inadequate Omega coverage in this region.

Figure 3 presents the frequency of downtime occurrences for each transmitter, grouped according to duration given by the three time intervals shown (2 to 5 minutes, 6 to 30 minutes, greater than 30 minutes). Most outages greater than 30 minutes were scheduled. Argentina had the greatest number of outages greater than 30 minutes, mainly occurring during maintenance time. Significant outages, in the range of 6 to 30 minutes, were completely unscheduled by Norway, Liberia, LaReunion, and Trinidad; the same holds true for the 2- to 5-minute range for these transmitters. In general, however, public notification of projected downtime has improved from the previous year at all transmitters.

SUMMARY

1. During 1979, four triple outages occurred; three lasted less than 7 minutes (minimal effect on Omega navigation), but the fourth lasted 33 minutes (Japan had transmitter overload during the period when Norway was down for extensive antenna repair and Argentina was down for annual maintenance).

2. The majority of dual outages occurred in March and early April when both Norway and Argentina were down for an extended period of time (5.5 days). Most dual outages occurred when one station was down for annual maintenance. Only one major dual outage (28 minutes) involved stations of which neither was scheduled to be off-air (North Dakota for emergency tower repairs, and Trinidad during commercial power failure on June 29, 1979).

3. The number of occurrences of simultaneous outages (of specified ranges of duration) during 1979 was comparable with that during 1977; the number for 1978 was higher, since most transmitters were then being modified to transmit their unique frequencies.

4. The 5.5-day loss of Norway - Argentina signals in March reduced Omega coverage to theoretically marginal levels in the North Atlantic west of Africa and north of South America (see figure 2).

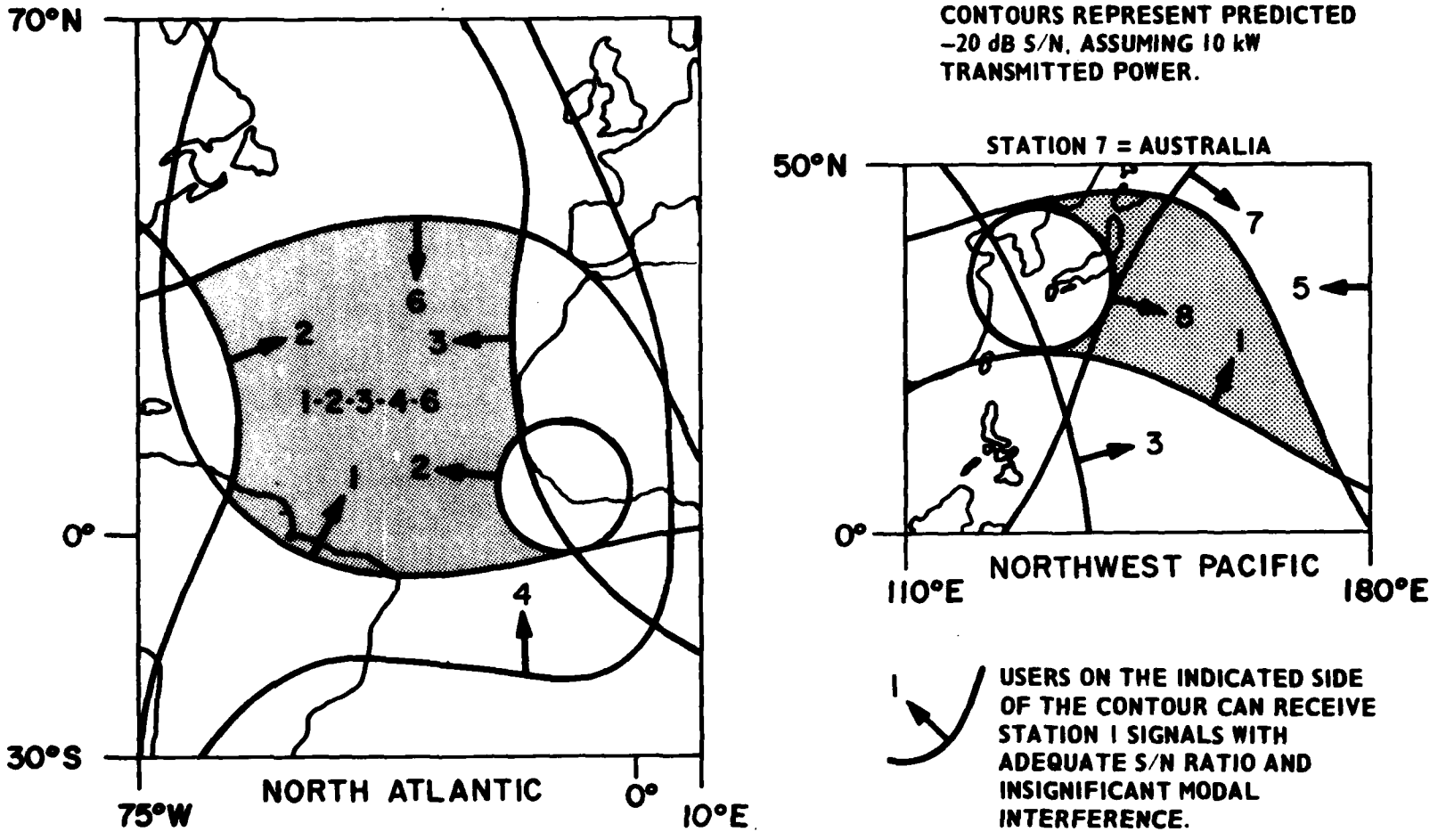


FIGURE 2. COMPOSITE COVERAGE DIAGRAM, LOCAL SUMMER NOON

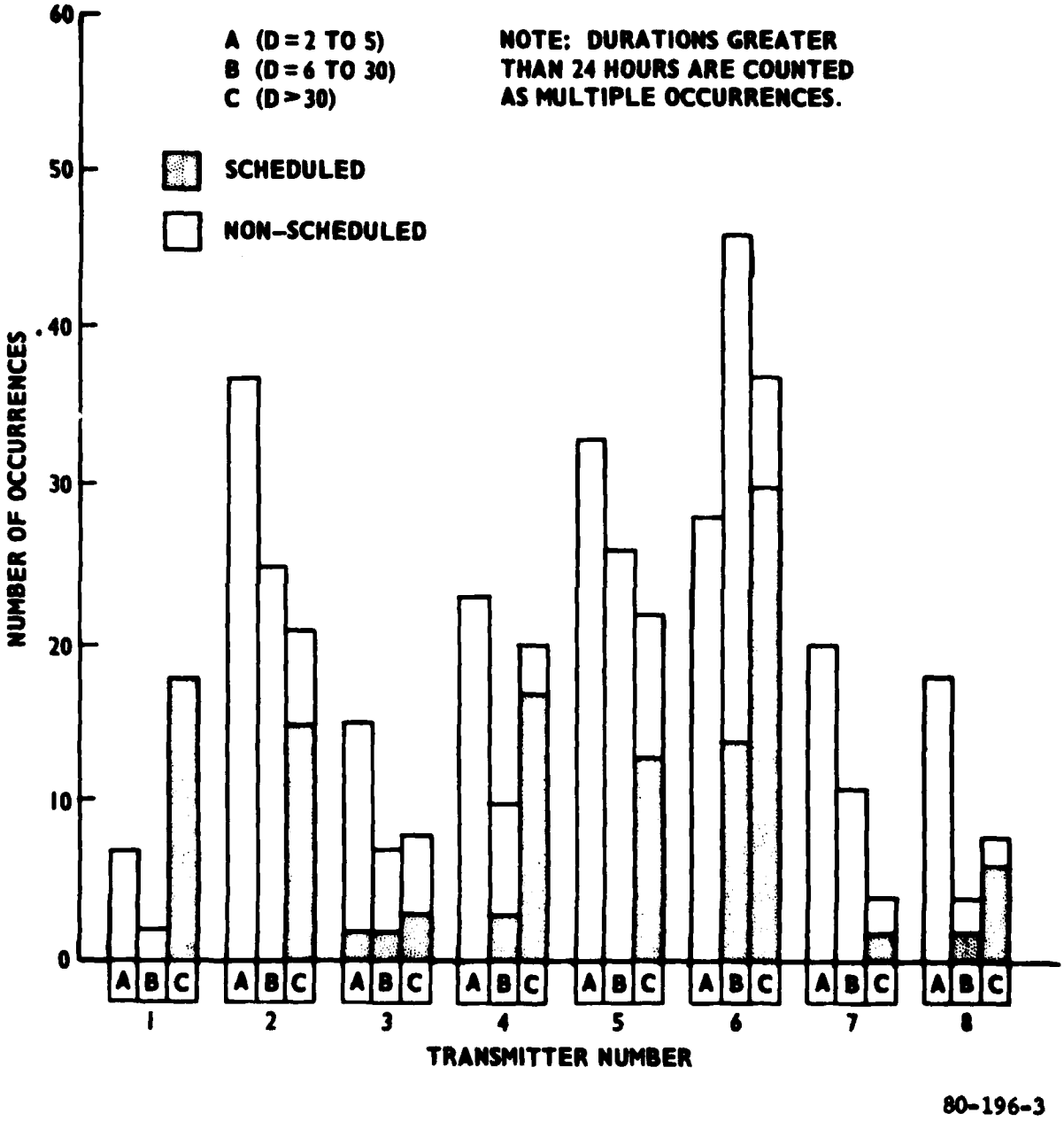
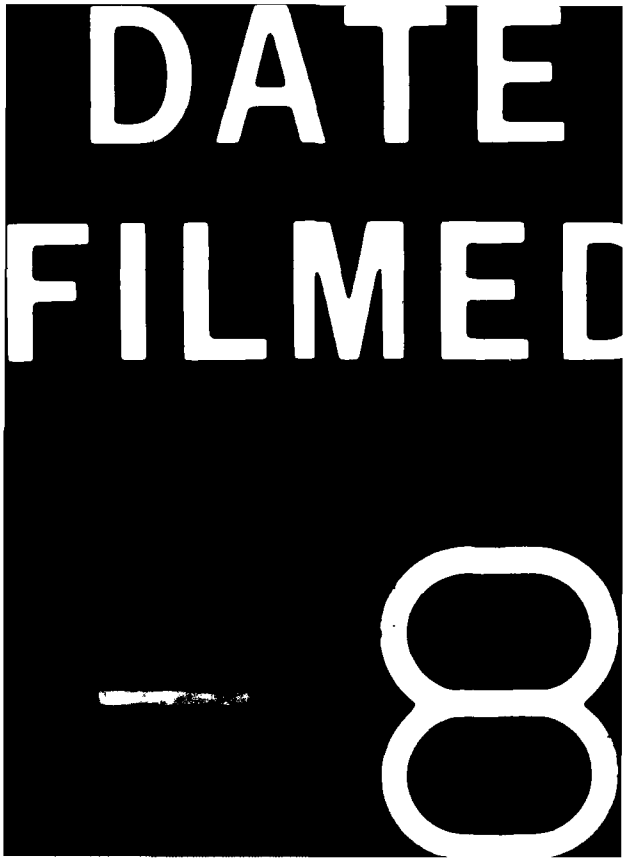


FIGURE 3. NUMBER OF OCCURRENCES OF OFF-AIR TIME OF DURATION D (MINUTES)

5. A measure of signal reliability was obtained by calculating the yearly percentage of transmitter downtime. Total downtime (both scheduled and unscheduled) was near 4 percent for four transmitters (Norway, LaReunion, Argentina, and North Dakota) and was less than 3 percent for the other four stations. This represented an increase in yearly downtime from the previous year for Norway and North Dakota; Hawaii and Japan showed a significant decrease in yearly downtime.

Yearly percentage of all unscheduled downtimes was highest for North Dakota (0.6 percent) and LaReunion (0.4 percent), while the other transmitters averaged 0.1 percent; these values are approximately one-half the magnitude of the maximum values exhibited the previous year, indicating that there was an improvement in prior notification of transmitter downtimes.

6. The average of the cumulative downtime during 1979 annual maintenance was 7 days, identical to the previous year. Actual cumulative downtime varied from 0.3 days (Norway) to 13 days (LaReunion); the maximum of 13 days compares to the previous year; whereas, the minimum value has decreased from 2 to 0.3 days.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